THE SCALE-EXPANDING COSMOS THEORY

This theory of cosmological scale expansion may provide the missing link between general relativity and quantum mechanics and is in better agreement with astronomical observations than is the Big Bang theory.

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1. Introduction

What is your opinion about the Big Bang (BB) theory? Maybe you have come across speculations that our universe was spun off from a "mother universe" or that it was created in an extremely huge quantum fluctuation. The problem with this, as with any other idea trying to explain the creation of the universe, is that we never will be able to confirm it; the creation scenario will always remain nebulous.

Before the Big Bang idea gained popularity in the middle of the 20th century, most people believed that the world exists eternally. In fact, an eternally existing universe was championed by Parmenides some 2,500 years ago. He argued that either the universe exists or it doesn't exist. If it exists, it obviously cannot have been created from something that does not exist, because non-existence means nothingness. *Therefore, the universe must always have existed.* This line of reasoning makes perfect sense, but the mind reels when confronted with the idea of eternal existence.

However, there is a new cosmological model, the Scale-Expanding Cosmos (SEC) theory, which allows perpetual existence. This new model is mathematically simple, is internally self-consistent, and offers many advantages over the BB theory, for example:

- The SEC theory is a comprehensive theory developed from first principles.
- The SEC theory better agrees with actual astronomical observations than does the BB model.
- The SEC theory is internally self-consistent. It addresses a range of existing problems that previously appeared to be unrelated.
- The SEC theory explains what makes time progress.
- The SEC theory provides the missing link between general relativity (GR) theory and quantum mechanics (QM) theory and explains why there is a quantum world.

This new theory implies a very different, yet simpler, world view. It involves new ideas, but is supported by observational data and conceptual clarity. The SEC theory is elegant compared to the BB patchwork.

This paper presents the philosophical and conceptual aspects of the SEC theory as well as some of its implications. The reader interested in the mathematical aspects or the observational details may consult my article in *Physics Essays* (Masreliez, 2006b) and my papers listed in the references.

2. How we got on the wrong track

The Big Bang theory was developed in an attempt to marry astronomical observations to the belief that there must have been a creation event. I will assume that the reader is familiar with the main justification for the Big Bang idea, which is the cosmological redshift. The frequency of light from galaxies is reduced; it is "redshifted" in proportion to their distances from us, which has been interpreted as a Doppler-type effect caused by their motion away from us. With this assumption, the Big Bang idea was born. If galaxies are moving away from each other, they must have been closer together in the past. Extrapolating this farther backward in time, we end up in an infinitely dense state—the Big Bang creation event.

This model of the universe also gained support from the fact that a spatially expanding universe may be modelled by GR, which gave the model physical credibility. Two additional observations seemingly support the Big Bang: the light element abundances and the Cosmic Microwave Background (CMB) radiation.

Advocates for the Big Bang scenario estimated the proportions of light elements like hydrogen, helium and lithium that could have been created in the BB event and found that they seemed to agree with what actually is observed in our present universe. Regarding the CMB, which was thought to be remaining radiation from the BB, they estimated the temperature to be about 50 degrees Kelvin.

Later, when additional observations revised the light element abundance estimates, the BB supporters repeatedly adjusted their assumptions about the BB to agree with the new observations. Also, when the CMB temperature was found to be about three degrees Kelvin instead of 50 degrees, the Big Bang scenario was adjusted to accommodate this new finding.

This set the stage for a development that still continues: whenever observations disagree with some particular prediction of the BB model, the model is adjusted to patch up the disagreement.

What cannot easily be accommodated is often blamed on "evolution", with the explanation that the observations from the faraway earlier universe do not agree with the BB model simply because the universe was different in the past.

It is not unusual that a patch that resolves one particular problem with the BB undoes another patch solving a different problem. Of course, this is not science; but, since nobody can ever know anything about the conditions during the Big Bang, it is always possible to explain away discrepancies by adjusting the model or by invoking evolution.

A different model gained its own followers, mainly in England: the so-called Steady State (SS) theory. The Steady State supporters accepted the expanding space idea but proposed that new matter continually is being created to fill up expanding voids between galaxies.

In this way, the universe could keep expanding forever without the BB. In the 1950s, the debate ran hot between these two camps, but the BB eventually won out because of the CMB.

The CMB is believed to be the afterglow of the BB event and should therefore have certain characteristics. In particular, it should have a Planck black-body spectrum. But this spectrum is very difficult to explain in the steady-state, expanding space scenario.

When measurements eventually showed that the CMB spectrum actually is very close to the black-body spectrum, the steady state theory lost ground and the BB theory became the accepted paradigm for the universe. This happened 40 to 50 years ago.

However, the more we learn about the cosmos from new observations, the clearer it has become that the BB model simply does not agree with observations. Science is now confronted with a very serious problem: thousands of papers over the years have been written on the BB model and hundreds of PhDs have been awarded for investigating particular aspects of this model. However, an open letter to the science community challenging the Big Bang was published in *New Scientist* in May 2004, signed by 33 well-known researchers. This letter now has over 150 signatories.

This reasoning suggests that the cosmological scale of space and time might be changing, which is the essence of the SEC theory.

3. The Scale Expanding Cosmos (SEC) theory

The main reason why challenges to the BB have failed is that, since the demise of the Steady State theory, no competing theory has been available. Even if you sense that the BB must be wrong, it is difficult to challenge it if you cannot suggest a better model. However, this has now changed; a better model now exists. This new model resolves many cosmological puzzles and is so simple and elegant that you might wonder why nobody has thought of it before. Here it is in just a few words...

The universe expands by changing the scale of both space and time.

When the length of a metre (or foot) expands, the pace of time slows down, making time intervals like the second longer in proportion. This new model explains all cosmological observations including the CMB without resorting to speculation or evolution. In the SEC, the CMB is simply thermalised radiation including starlight, which over aeons has assumed a black-body spectrum by redshifting. Four-dimensional scale expansion, which preserves the black-body spectrum, makes this possible (Masreliez, 2004a).

The light element abundances may be explained as resulting from active galaxy nuclei and quasars, which often are seen ejecting gas in jets (Masreliez, 2004b). Furthermore, the SEC theory tells us what is causing the progression of time and provides the missing connection between GR and QM (Masreliez, 2005a); and it turns out that black holes cannot form (Masreliez, 2004c).

As Einstein showed us, it is often the hidden presumptions that cause us to misunderstand the true nature of the world. He showed that the pace of time might differ between objects in motion and objects at rest and that a gravitational field also might influence the pace of time. Thus, he challenged the presumption that the pace of time always is the same everywhere.

The SEC theory goes one step further by proposing that *the pace of time also might change with time*. When space expands, the pace of time slows down.

One reason why Einstein might have overlooked this possibility is that his general relativity theory does not have any provision for modelling a decreasing (proper) pace of time; it assumes that the pace of time for an object at rest always remains the same.

4. How the SEC theory explains the universe

Let's consider the following thought experiment. Imagine that you are the Creator, facing the task of creating something, for example an apple, from nothingness. What size should you make this primordial apple? It occurs to you that since there is no reference, you could actually make it any size, like a pea, a basketball or even like the Earth, provided you create all atoms in the apple to scale. And since atoms oscillate, you would also have to adjust the pace of time to match.

With this primordial apple as a start, you can then create the rest of the world in proportion. If this isn't true, there must be something in "nothingness" that determines the scale of things, which contradicts the concept of nothingness.

We conclude that physically equivalent universes might exist at different scales and that no particular cosmological scale is preferred; the cosmos is "scale-equivalent". This reasoning suggests that the cosmological scale of space and time might be changing, which is the essence of the SEC theory.

A scale-expanding cosmos has no beginning or end; the scale may continually keep expanding forever. Thus, there is no BB event to consider, so eliminating the most troublesome aspect of the BB theory. An observer in the SEC, like you or I, expands together with the universe and will not notice the expansion locally, since everything else in our environment, including material objects, expands at the same pace.

Although we cannot notice the expansion locally, its effects can be seen in the redshift of light from faraway galaxies. However, this redshift is not due to recession. If we were able to extend a very (very!) long measuring tape between two galaxies, we would find that they remained in the same relative positions since the tape expands together with everything else. And if we timed a light beam between the galaxies, we would find the same constant time interval since the pace of time slows down when space expands.

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Thus, relative positions of galaxies remain the same. You might say that the universe expands without expanding! The cosmological explanation is in *scale*, which does not change relationships between the three spatial metrics and the temporal metric. The cosmological redshift therefore is an expanding space-time effect.

Furthermore, since universes of different scales are physically equivalent, the scale expansion may progress without cosmological ageing. You may object to this because it seems to violate thermodynamics by suggesting that the universe is a perpetual motion "machine". However, this conundrum is resolved by the previously unanticipated slowing progression of time, which has the effect of inducing cosmological energy.

Although the idea of cosmological scale expansion seems natural to most people without scientific training, people in science might have a hard time with this simple idea because *physically equivalent cosmological scale expansion cannot be modelled by GR*. Since general relativity and quantum mechanics are the two central pillars of modern physics, it is unthinkable for people in academia to consider anything that might violate GR.

But, scale expansion is such a simple and natural idea that it seems wrong to abandon it simply because it cannot be modelled by GR. Quoting Carl Sagan from his book *Cosmos*:

We must understand that the cosmos is what it is and not confuse how it is with what we wish it to be. The obvious is sometimes false; the unexpected sometimes true.

5. The SEC theory implies new physics

Let's try to model scale expansion. We have to come up with a way to model how time expands relative to time. We might try to use differential methods and form the derivative of time with respect to time, which is dt/dt. Since dt/dt always equals one, we conclude that time always progresses at the same pace relative to itself. This doesn't help. However, if instead of time we use the cosmological scale as an additional parameter, we could model a scale that increases with time in GR. However, we will then get a cosmological model that changes with time, and lose the fundamental feature of cosmological scale-equivalence. This model would lead to a BB-type scenario.

This problem occupied my mind for about two years. I found that this also had been an insurmountable obstacle for other investigators, who in the past followed the same trail of thoughts. Finally I concluded that GR must be *incomplete* since it cannot model scale-equivalent cosmological expansion. At first this was a disappointment, but I thought that scale expansion was such a simple and pure idea and that it should be possible, even if it couldn't be modelled by GR. After having further investigated the properties of the SEC and finding that it accurately models the world as we see it, I gradually became convinced that GR should be generalised to make possible *discrete* scale adjustments. I found that if the cosmological scale were to change in small and rapid increments, the SEC could be modelled by GR! GR is "blind" to discrete, stepwise scale changes; Einstein's equations remain unaffected. If the cosmological expansion were to occur in discrete scale increments, thus being treated as a "fifth dimension" beyond the four space-time dimensions, GR could still be used.

If we accept this solution to our modelling problem, we will also gain two very important advantages. First, the progression of time is explained; *the incrementally increasing scale makes time progress*, which also explains why it has been impossible to model the progression of time in GR. The second advantage is that a discretely expanding scale would provide a direct link between general relativity and quantum mechanics (see also section 10).

6. Cosmic Drag

One immediate consequence of the Scale Expanding Cosmos model is that relative velocities of freely moving "particles" (I take a particle to mean any object with positive rest mass) will slow down with time. Relative velocities much lower than the speed of light will diminish exponentially with time, with a time constant that equals the Hubble time. The Hubble time is the age of the universe in the BB model, which is about 14 billion years. This means that relative velocities between galaxies tend to be quite small because of cosmic drag. They may be estimated from observations and typically are less than one per cent of the speed of light. This has been difficult to explain in the BB picture where numerical simulations indicate that relative velocities ought to be a lot higher than what is observed. On the other hand, particles initially moving at the speed of light—for example, photons—will continue to move at the speed of light. This is perhaps strange, but it follows directly from GR (Masreliez, 2004a).

Cosmic drag will also slow down relative rotating motion, causing angular momenta to decrease exponentially with time. As a consequence, stars in motion in a spiral galaxy will follow spiral trajectories on their inward paths and gravitational attraction between them will form the beautiful spiral arms we observe. Thus, the SEC theory would also explain the formation of spiral galaxies, which has been a previously unresolved problem (Masreliez, 2004b).

Furthermore, cosmic drag should influence the planetary motions in our solar system, causing the planets to approach the Sun slowly in spiral orbits. The Earth would approach the Sun by about 20 metres per year and the angular velocity would accelerate. This effect is extremely small and therefore has gone unnoticed until very recently. We haven't detected this spiralling motion earlier because the concept of time in astronomy was in the past determined by the rotation of the Earth and by the motion of the Earth around the Sun. Obviously, if one defines the length of the year as the time it takes for the Earth to circumnavigate the Sun, any possible acceleration of the Earth in its orbit around the Sun will be undetectable because of the way we have defined time.

This made it impossible to detect the spiralling motions before the introduction of atomic time in 1955, but now, after observations have been made for 50 years with access to atomic time, discrepancies are starting to appear, showing that currently we have a mysterious, unresolved problem in astronomy. This is a very interesting "breaking news" situation, which soon may confirm the SEC theory.

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7. Estimating the planetary orbits

Nobody knows when the first human raised her eyes to the heavens and noticed that not all stars were stationary but that a few of them seemed to wander. Although the significance of these wandering stars was unknown, they were recognised as being special, and people started to map and predict their motions.

Today the planetary orbits are still of central importance to the NASA space program. Predicting the planetary orbits, or the planetary ephemerides as they now are called, is one of the responsibilities of the Jet Propulsion Laboratory (JPL), which is a division of NASA.

Traditionally the planetary orbits were estimated with the help of Newton's laws of motion and his law of gravitation, by which the planetary orbits are elliptical. Thus, planetary orbits were in the past fitted to elliptical orbits based on optical observations, which determined the orbital parameters. In this process of fitting the orbital parameters, the time-base was also estimated and adjusted for best fit to the observations. This was a very difficult and time-consuming task, which later was simplified by the use of digital computers.

By the middle of the 20th century, the procedure and method of computing the planetary ephemerides were well understood, and advanced computer programs were developed that allowed us to take into account gravitational influences between the planets as well as the larger asteroids.

The time-base was still estimated together with the planetary motions.

In the middle of the 20th century, a new time standard entered the scene. This was atomic time, based on sub-microscopic oscillation. This new time standard was adopted by astronomy in 1955; hence, all observations since then have been tied to atomic time.

After the adoption of atomic time, it was suggested that the ephemerides should be based on atomic time rather than on an estimate from planetary motions. However, this proposal was rejected by JPL (Standish, 1998). In the 1970s it became possible to refine the orbits further by making use of radar ranging measurements between the planets, which are at least one order of magnitude more accurate than the optical data.

Today, the ephemerides are primarily based on radar ranging data between the Earth and the other three inner planets. Optical observations are only used for the outer planets.

JPL rejects the optical data for the inner planets because not only are the optical observations less accurate, but they also show a consistent bias—a bias that repeatedly has been confirmed by several independent investigators.

Since the ranging data are superior to optical data, JPL has ignored this discordance, suspecting that the optical discrepancies are due to some kind of systematic error, but nobody knows what might be causing it. Also, when fitting the ranging data, earlier measurements from the beginning of the ranging program do not seem to fit.

8. Explaining the planetary discrepancies

In order to understand what may be going on, we have to recall a fundamental aspect of GR.

General relativity theory describes the world using coordinates for space and time that may be selected more or less freely. We might think of a specific coordinate selection as a particular pair of glasses that lets you view the situation in a certain way, but GR does not tell us which choice of glasses is the "right" one.

In the SEC theory, space is flat but space-time is curved due to the accelerating scale expansion. This causes the cosmological redshift and cosmic drag. But, to every curved space-time there always corresponds a locally flat space-time, just like a planar surface locally approximates a curved surface. Thus, there exists a locally flat coordinate representation even here in our solar system. In this coordinate system, the planetary orbits are determined by Newton's laws; the orbits are "Newtonian" (with relativistic corrections).

If there is cosmological curvature as predicted by the SEC theory, the cosmological time-base—which I will assume is proportional to atomic time and is incorporated in barycentric dynamical time (TDB)—will differ from the ephemeris time-base determined from the orbits, which JPL calls "T_{eph}".

However, fitting the range measurements to Newtonian orbits could lead to the wrong conclusion. *By fitting the measured distances to essentially Newtonian orbits, the computer program might automatically select the locally flat coordinates for which Newton's laws apply.*

This will of course create excellent agreement with the ranging measurements, which JPL apparently thinks confirms the validity of its approach. But this is circular reasoning, since the coordinates for which the orbits become Newtonian may differ from the cosmological coordinates. In particular, the T_{eph} time-base may not be proportional to atomic time.

If the SEC theory is right, T_{eph} accelerates relative to atomic time.

In the construction of the ephemerides, JPL fits atomic time as closely as possible to T_{eph} in the belief that T_{eph} is identical to atomic time except for a scale factor. By this procedure, the maximum difference between T_{eph} and atomic time predicted by the SEC theory could be reduced to merely 0.10–0.15 seconds during a 30-year observation interval. This corresponds to a few kilometres' ranging error, which currently also is the estimated accuracy of the JPL ephemerides.

However, as already mentioned, earlier ranging observations taken in the beginning of the ranging program no longer agree with the updated ephemerides and therefore, like the optical observations, are considered inaccurate. It is possible that both this earlier ranging data and the optical data would fit the ephemerides if the SEC model were adopted. We might be on the verge of a discovery of historical significance!

9. The question of a cosmological reference frame

After this hopefully intriguing detour, let us return to highlighting a few additional properties of the SEC theory. The existence of cosmic drag would invalidate Newton's first law of motion and cause a major revision of science, which partly may explain the total silence with which the SEC theory has been met. But, on the flip side, it would resolve a festering problem since the days of Newton: the question of a cosmological reference frame.

In his famous spinning bucket experiment, Isaac Newton observed that the surface of the water in a spinning bucket becomes concave and he concluded that the bucket somehow "senses" that it is spinning. But, spinning relative to what? It is not the Earth because the planets are subjected to the same force in their motion around the Sun, and it is not the Sun since stars in a galaxy are subjected to the same force.

Newton concluded that a frame of absolute universal rest must exist, and this became the subject of a celebrated debate between Clark, who spoke for Newton's position, and Leibniz, who contended that all motion is relative.

From the time of Newton until Einstein's special relativity theory appeared in 1905, people were convinced that there was a cosmological reference frame defined by the "aether", which was believed to be some undefined kind of "plenum" in absolute rest carrying light and the electromagnetic field. Einstein did away with the aether, but only for a relatively short time—the 11 years between 1905 and 1916.

After introducing GR in 1916, he gradually changed his position. By the end of his life, Einstein was convinced that space-time was a new form of aether that somehow served as a reference frame for inertia.

Cosmic drag would resolve this problem by defining the cosmological reference frame as the frame toward which all motion converges. Thus, in the SEC, the cosmological reference frame is self-induced by bootstrapping caused by diminishing relative velocities and rotations. This should be good news, since physics desperately needs a cosmological reference frame to explain the phenomenon of inertia (Masreliez, 2006a) and of non-local influences of the quantum world. It also would explain the CMB dipole, which indicates that the solar system is in motion relative to the very distant universe at about 350 km/sec.

10. The SEC explains the quantum world

One of the most embarrassing problems of contemporary science is that there seemingly is no connection between its two dominant theories: general relativity and quantum mechanics. These theories successfully model different aspects of the world, but they are starkly different in both philosophical approach and scope. GR applies to gravitation and cosmology, while QM deals with the sub-microscopic world. Although these two theories describe different aspects of the same universe, it is perplexing that they are so different and are incompatible.

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The SEC theory provides a simple solution to this dilemma, since it allows quantum mechanics to be derived from general relativity.

The key to understanding what is going on is the incremental scale expansion of the SEC theory.

Scale expansion means that the length of a fixed distance like a metre slowly expands and that the pace of time slowly decreases. If this were a continuous process we would not notice it locally, but according to the SEC theory it is an incremental process. The scale expands a tiny bit and then we "jump into" the new scale by a discrete step. Like a child who repeatedly grows out of her clothes and gets them replaced by new, larger clothes, we repeatedly grow out of our scale before jumping into the bigger scale by abruptly changing the pace of time.

This expansion process is of course new and at first we might not believe it can be true. However, it is possible to model this process in GR by considering oscillating scale (metrics). We find that GR with oscillating metrics describes the quantum world! This is presented in my paper (Masreliez, 2005a), where I show how the QM theory may be derived from the GR theory. Now we understand that the quantum world is a direct consequence of incremental cosmological scale expansion!

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11. Can any cosmological model really describe the universe?

A cosmological model not only describes properties of the universe but, more importantly, it reflects what we know. We are constrained by our presumptions, biases and current level of insight. This has always been true. Ancient people perceived the universe as filled with mythological creatures. We know more now, but we still must use familiar concepts to describe the cosmos. Science tries to explain Nature by constructing models from which various features may be portrayed and predicted. But these models can be no better than the "material" we use to build them with, this "material" being known and accepted epistemology.

From our past experience it is clear that the old models of the universe were inadequate simply because people did not know enough, and this also applies today. Any model we can conceive of is bound to be incomplete or perhaps even wrong; we simply do not know enough yet, and we will never know everything.

The only thing we can hope for is a model that makes sense to us with our current level of understanding. A good model should agree with observations and be internally consistent. Any cosmos model that does better in this regard is an improved model, even if it means that we have to use new building materials. This is the way progress is made.

With our current knowledge, the model should seem right, at least until we learn more. Therefore, we should not believe any model is the "last word". We should realise that a cosmos model is only a tool for us to try to make better sense of the world.

The BB and the SEC theories should be viewed with this in mind.

That said, it should be obvious to the reader that at this time the SEC theory is a better model of the universe than the BB model. The minimum requirement that a model should agree with observations and be internally consistent is not satisfied by the Big Bang.

The Scale-Expanding Cosmos theory explains many previously unresolved cosmological puzzles. It agrees with observations without resorting to strange assumptions like "dark matter" or "dark energy", and observations agree with the SEC model's prediction without the need for speculation on decelerating expansion or accelerating expansion or on evolution. Furthermore, this new model explains what causes the progression of time and why there is a quantum world. ∞

Author's Acknowledgements:

I would like to thank Richard Moody, Jr, for suggesting that I have this essay published in *NEXUS* magazine and for his helpful comments. I would also like to acknowledge Del Miller's editorial suggestions.

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